MATCHED FIELD TOMOGRAPHIC INVERSION FOR GEOACOUSTIC PROPERTIES

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Award #: N00014-96-1-0721
Shallow-water acoustics

LONG TERM GOALS

The geoacoustic properties of the ocean bottom, including sound speed profiles, densities, attenuations and sediment layer depths, have a significant effect on sound propagation in shallow water. The long term goal of this work is to develop a new tomographic inversion method based on matched field processing for estimating geoacoustic properties.

OBJECTIVES

Matched field tomographic inversion is a relatively new approach (Tolstoy, 94) that is specifically designed for rapid, high resolution estimation of ocean bottom properties. The new tomographic technique makes use of multiple vertical line arrays, and extends the MF inversion method to 3-D anisotropic environments, i.e. variability in depth, range and cross-range. An experiment to obtain acoustic field data at a multi-array system was successfully carried out using broadband sound sources in the Haro Strait Primer Experiment in June 1996. The objective of the current study is to investigate the performance of coherent and incoherent matched field processing in designing an inversion method for the Haro Strait data.

APPROACH

An extensive broadband data set was collected in the Haro Strait experiment, using light bulbs as sound sources. The first step in investigating the general tomographic inversion problem has been to develop a method for inverting broadband data. A method based on waveform matching was developed, using simulations for a single source and array geometry in order to demonstrate the approach on a conventional experimental system. The method employs ray theory to calculate replica fields, and uses a new approach to the global search process that is capable of estimating distributions of model parameter values that optimize the field data.

WORK COMPLETED

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
30 SEP 1997		**00-00-1997 to 00-00-1997**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Matched Field Tomographic Inversion for Geoacoustic Properties	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **University of Victoria,School of Earth and Ocean Sciences,PO Box 3055,Victoria, B.C. V8W 3P6,**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**3**	

Data quality has been verified, and specific sets were selected for analysis. Most of the research effort was concentrated in designing the broadband inversion method. Two approaches with different global search techniques were investigated. The first method was based on a two-stage grid search. Although this approach was effective in estimating model parameters, a new method was subsequently developed that was capable of providing a statistically meaningful measure of the confidence of the estimated values. Both methods were applied to Haro Strait data for a single source and array to estimate the geoacoustic profile at the array site.

RESULTS

A new global search method has been developed for matched field inversion. The method makes use of the heat bath algorithm for simulated annealing. However, unlike standard simulated annealing, the system is not cooled to an optimal solution. Instead, the process is paused at a temperature near the annealing point, and the distribution of possible models that provide a good fit to the data is sampled. The method also determines an optimal set of independent parameters, based on the covariance matrix of the data, and adjusts the annealing temperature adaptively to account for parameters with different sensitivities. The method is thus capable of determining correlations between geoacoustic model parameters, and providing an estimate of the error in the estimated parameter values. The method was applied to the Haro Strait data for a single light bulb and one of the arrays (Chapman et al, 1997). Estimated parameter values were consistent with ground truth data that were obtained in the experiment.

IMPACT/APPLICATIONS

The inversion method uses a novel global search technique that provides a meaningful error estimate. This approach holds interest for seismic as well as acoustic inversion.

TRANSITIONS

The broadband light bulb data from the Haro Strait experiment were used by collaborators from MIT in an ocean acoustic inversion of the sound speed profile over the are enclosed by the arrays (Elisseeff et al, 1997), and by researchers at the Defence Research Establishment Atlantic in an investigation of the source level of light bulb implosions (Heard et al, 1997). Also, Alex Tolstoy intends to make use of the broadband data in her investigations of geoacoustic inverse methods.

RELATED PROJECTS

This work on geoacoustic inversion is related to several other projects currently funded by ONR; I have had discussions with investigators in each project to describe the results of the Haro Strait experiment. These projects include: the Yellow Sea experiment (Peter Dahl, APL, Washington); the SHELFBREAK Primer experiment (Jim Lynch, WHOI and

Kevin Smith, NPS); and the geoacoustic inversion investigations of Mediterranean Sea data by Alex Tolstoy and Peter Gerstoft.

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